

Use soil test to inform change from phosphorus build-up to maintenance for more profits

Authors: Mike T F Wong¹, David Weaver² and Richard Bell³

Affiliations: ¹CSIRO Floreat, ²DAFWA Albany, ³Murdoch University Murdoch

KEY MESSAGES

- Phosphorus management is characterized by an initial build-up phase that corrects P deficiency followed by a maintenance phase after soils reach the Colwell P values needed for near maximum production (critical values). For several decades, twice more P was applied than was removed in harvested grains across Western Australia. In the grains region of WA, the change from build-up to maintenance that uses less P has not occurred.
- Continued build-up of soil P has resulted in 87 % of wheat paddocks analysed by Wesfarmers CSBP in 2008-10 exceeding their critical values. A transition to the maintenance phase is overdue as there is no yield or financial benefit from P build-up beyond critical values (except where acidity, water repellence and root disease restrict P uptake by roots- see paper by Scanlan et al in this Crop Update) but there are fertiliser and potential environmental costs.
- It is likely that significant areas of your farm or your paddock already exceed critical values. You need to soil test your paddock to determine if a change from build-up to maintenance practice will improve your profits. Researchers need to develop the guidelines for developing maintenance practices. Money freed by the transition to maintenance should be re-invested to treat commonly occurring soil constraints such as acidity and potash deficiency to improve efficiency, production and profits.

AIMS

Our aims are to assess and improve the management of P in the WA grains industry for more profits and better environmental outcomes.

BACKGROUND

Soils across the grains cropping regions of Western Australia were inherently low in P and other nutrients. Development of agriculture would not have been possible without the use of P and other fertilisers. In these soils, profitable rates of P resulted in increased yields and a gradual build-up of soil available P (measured as Colwell P). Once P deficiency is corrected and the Colwell P values for near maximum crop production (critical values) are reached, the recommended practice is to maintain the soil at these critical values. This prevents reversion to deficiency and risk of yield and profit loss. The P maintenance practice uses less P than the build-up phase. The amounts of P applied during maintenance are designed to balance (1) removal in harvested grains and other products such as hay and sheep sold off farm (2) amounts of fertiliser P that becomes tied-up by strong adsorption with soil and (3) unavoidable losses due to leaching, runoff and erosion.

The WA cropping industry has a long history of P use that started with the development of the industry. It is now time to assess if we have succeeded in correcting the P deficiency and if we are ready to move to the maintenance phase. This is also an opportunity to assess what other soil constraints are limiting production and profits so that money freed-up by transitioning from build-up to maintenance could be re-invested in managing these constraints.

METHOD

We first determined (1) the amount of P applied as fertilisers to crops in WA and (2) the amount of P removed in harvested grains by multiplying grain yield by the P content of the grains. Next, we expressed the data as the P balance efficiency of the paddock or farm. P balance efficiency is the amount of P removed expressed as a percentage of the amount applied. For example, if we removed 5 kg P/ha in the form of P contained in grains and we applied 10 kg P/ha as fertiliser, then the P balance efficiency is $5/10 \times 100 = 50\%$. P

balance efficiency allows us to assess along with soil test P data if we are building-up, maintaining or depleting soil P. This analysis was done at paddock to farm scales using data from the literature, unpublished data from colleagues and from farmer surveys.

Building-up, maintaining or depleting soil P can all be the best management decision depending on whether the soil P status is deficient, sufficient or well above critical values. We therefore next assessed soil P status. We are grateful to Wesfarmers CSBP (<http://www.csbp.com.au>) for providing the chemical analysis of 109, 000 soils sampled (0-10 cm) in 2008-10. The soil data on Colwell P and P Buffering Index (PBI measures P sorption or the propensity of the soil to tie-up P) allowed us to classify these soils according to exceedance of critical values. Soil Colwell P and PBI also allowed us to determine the concentration of Dissolved Reactive P (DRP) in soil and the risk that this may pose to the environment. The soil analysis data also provided information on soil acidity and potassium availability so that an assessment could be made on likely soil constraints to production.

RESULTS

The median annual fertiliser P input for cropping was 11.3 kg P/ ha and for sheep grazing it was similar (9.8 kg P/ ha). Median P outputs in harvested materials differed significantly between cropping (5.6 kg P/ ha) and sheep grazing (1.1 kg P/ ha). This resulted in very different PBE which was 49 % for grains cropping and 11 % sheep grazing. The typical values are given in Table 1. The landscapes on which crop and sheep production are based are therefore typified by positive balance and accumulation of P. Based on these PBE figures, in cropping about twice more P is applied than is removed in harvested grains products. In sheep grazing, the figure is about ten times more due to low P outputs in sheep and wool.

Table 1. Typical P inputs from fertilisers, P outputs from grains, animals and wool, P balance (P inputs minus P outputs), and P balance efficiency (PBE, %) for cropping and sheep. Adapted from Weaver and Wong, 2011.

	Cropping	Sheep
P inputs (kg/ha)	11.2 – 12.3	9.0 – 12.1
P outputs (kg/ha)	5.1 – 6.4	0.9 – 1.4
P Balance (kg/ha)	5.4 – 7.3	8.0 – 10.9
PBE (%)	42 – 53	9 – 12

These current estimates of PBE are similar to those reported 20 years ago suggesting prolonged on-going P accumulation in soil (McLaughlin et al., 1992). The positive outcome of this P build-up practice is successful control of P deficiency. We estimate that about 87% of the wheat paddock soil samples examined are no longer P deficient (exceed their critical values). In general, coarser textured (sandier) soils with low P buffering Index (PBI) are more likely to have exceeded their critical values than finer textured (more loamy or clayey) soils with higher PBI. Sandy soils of the northern shires of WA have a higher frequency of samples with sufficient P than loamier soils of the southern shires (Neuhaus et al., 2011). A detailed breakdown of soils that exceed their critical values is given in Table 2. Most soils (86%) in this data set have PBI <70 and between 82 and 93% of soils in this PBI range exceed their critical values. These soils will not give a yield benefit or financial benefit from P build-up beyond critical values (except where acidity, water repellence and root disease restrict P uptake by roots- see paper by Scanlan et al in this Crop Update) but there are fertiliser and potential environmental costs due to contamination of water bodies.

The amount of Dissolved Reactive P (DRP) in soil solution poses a potential risk to the environment if this solution is transported to water bodies. In most cases the concentration of DRP exceeds the ANZECC and ARMCANZ (2000) guidelines for ecosystem health (Table 2). This risk increases when soil test P increases beyond critical values for production.

The high frequencies of soils that exceed their critical values suggest that most farmers should expect significant areas of their land to have sufficient P and to no longer need build-up. Soil testing will inform these farmers if it is now time to adopt maintenance practice and reap the benefits of successful control of P deficiency.

Table 2. Phosphorus Buffering Index (PBI) profiles for soil samples in south west WA and associated percentages of soils within each PBI group that exceed the ANZECC and ARMCANZ (2000) dissolved reactive phosphorus (DRP) guidelines for ecosystem health. Adapted from Weaver and Wong, 2011.

PBI Range	PBI Profile (% sample in PBI range)	% exceedance of DRP guidelines	Critical Colwell P values for near maximum wheat production mg P/kg	% samples exceeding critical value to achieve 90% of maximum wheat production
<5	2	99.6	7	88
5-10	8.4	99.9	10	91
10-15	10.8	99.9	12	93
15-35	42.7	99.9	16	92
35-70	22.4	99.8	22	82
70-140	8.7	99.1	29	54
140-280	3.8	95.9	38	39
280-840	1.2	75.6	N/D	N/D

Figure 1 gives an insight on how quickly soils will reach their critical values. In most cases this is reached within 20 years of continuous P build-up. It is more rapid in sandy soils with low PBI than in loamy and clayey soils with higher PBI. The variation in texture from sandy to loamy and clayey soil types across a paddock is therefore going to result in spatial variation in P status and this has been measured in several paddocks in WA (results shown separately).

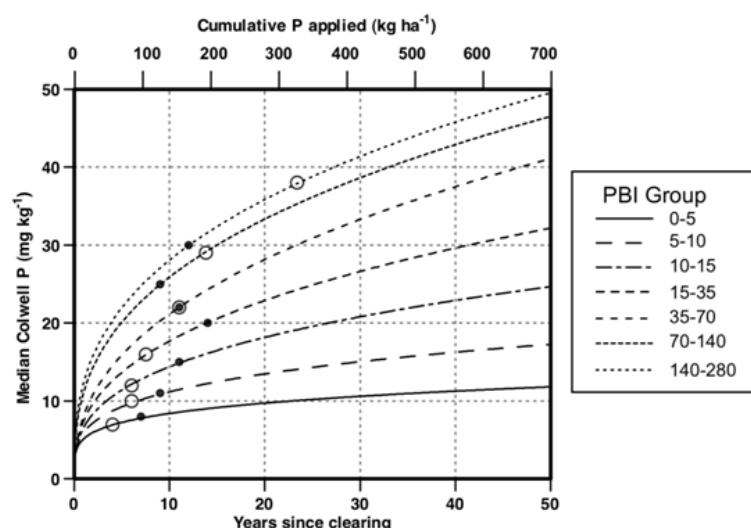


Figure 1. Temporal changes in Colwell P for soils grouped according to their P buffering index (PBI) values. Overlain points show critical Colwell P values to achieve 90% of maximum production for wheat (O) compared with pasture (●). Upper x-axis shows estimated cumulative P applied assuming annual P input of 14 kg P ha⁻¹. Reproduced from Weaver and Wong, (2011).

Any soil constraints that decrease yield and P removal in harvested materials will decrease P balance efficiency and the efficiency of any other inputs including water use efficiency. Soil acidity is a common constraint in WA (Table 3). This limits root growth, nutrient and water uptake and yield.

Table 3. Percentage of Western Australian soils exceeding critical values of P for 90% of maximum wheat production and subject to other soil constraints. Adapted from Weaver and Wong, 2011.

Samples exceeding critical Colwell P to achieve maximum production 87

Samples with pH (CaCl ₂) < 5.5	70
Samples with Colwell K deficiency	8
Samples exceeding critical value to achieve maximum production and pH (CaCl ₂) <5.5	63
Samples exceeding critical value Colwell P to achieve maximum production and likely to respond to K	7

CONCLUSION

Growers in Western Australia have been successful in treating P deficiency on their farms. It is now time to communicate this success and to profit from it. The opportunity is to change P management from current build-up to maintenance practice. Maintenance will ensure that the adequate P status achieved by sustained investment in P is not lost. It uses less P than the build-up phase but maintains production at near maximum levels. This results in more profits and less environmental risks due to potential loss of P to water bodies.

Maintenance aims to sustain the soil P status at adequate levels by replacing the amounts of P (1) removed in harvested products (2) fertiliser P tied-up in soil and (3) unavoidable losses. Researchers need to determine what these amounts are for different soils and regions of Western Australia so that reliable maintenance recommendations can be made to growers. In the meantime, it is advisable to soil test and if above critical values, reduce the P application to replacement rates and to monitor soil and plant P concentration to fine-tune those application rates.

Many soils still have other constraints such as acidity and potassium deficiency that would limit the production and profits. It is important that money freed-up by using less P fertilisers is re-invested to ameliorate these constraints to lift the efficiency of the farm and profits.

KEY WORDS

Build-up, maintenance, soil test, soil constraints, acidity

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